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Behavioral and Nonbehavioral Risk Factors for Occupational Injuries and Health Problems Among Belgian Farmers

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ABSTRACT. Preventive interventions to reduce occupational injuries and diseases among farmers require an appraisal of the relative importance of the various risk factors. This paper describes the results of a cross-sectional study investigating determinants of occupational health and injuries among 510 Belgian farmers, looking at health-related behaviors (machinery use, animal handling, fall prevention, and pesticide use), as well as nonbehavioral risk factors (demographic characteristics, farm characteristics, and participation in safety training). Education level and number of employees on the farm were identified as nonbehavioral risk factors for injuries, with highly educated farmers and working with one employee associated with a higher injury risk. In contrast, none of the nonbehavioral factors were related to occupational disease. Unsafe machinery use, animal handling, fall prevention, and pesticide use were behavioral risk factors for injuries, with unsafe pesticide use representing the highest risk. Unsafe machinery and pesticide use were also risks for disease. Significant differences in self-reported behavior were found for gender, age, number of employees, and the interaction between age and education. The study highlights the importance of behavioral factors as determinants of occupational injuries and diseases among farmers, and suggests that tailored preventive interventions should be developed to accommodate for differences in these behaviors among subgroups of farmers.

KEYWORDS. Epidemiology, farm health-related behavior, farm safety behavior, risk factors

INTRODUCTION

Agriculture is generally recognized as a hazardous and unhealthy occupation. In the United States, agriculture, forestry, fishing, and hunting in 2008 had by far the highest fatal work injury rate of all occupational sectors, with 28.4/100,000 full-time-equivalent workers.[1] In Europe, agriculture is the fourth most hazardous occupational sector, with a mortality rate among agricultural workers of 12.4/100,000 in 1998.[2] Comparable rates have been reported for Canada, with a mortality rate among farmers of 13.7/100,000 between 1990 and 2005,[3] and for Australia, with a fatality rate of 8.9/100,000 between 1985 and 1996.[4] In New

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Zealand, the overall fatal injury rate for agriculture between 1985 and 1994 was 21.2/100,000, or almost a quarter of work-related deaths.[5] Occupational health problems related to farming include chronic back pain and hernia, skin problems, respiratory diseases, and poisoning.

To reduce the burden of these problems, preventive measures must be taken. This requires an accurate assessment and understanding of the risk factors leading to injuries and diseases. In this regard, a distinction can be made between demographic, environmental, and behavioral factors. Age and gender are important demographic factors related to farm injuries, with children and older men being identified as the most vulnerable groups.[6,7] Risk factors in the social and physical environment include low socioeconomic status,[7,8] farm size,[9,10] and seasonal conditions.[10–12] Behavioral risk factors, that is, practices related to injuries and occupational health problems of farmers, include the handling of livestock,[13–15]machinery,[4,16–18]and pesticides.[19,20] Incidents with animals are the main cause for nonfatal injuries, whereas unsafe use of machinery, and especially of tractors, is responsible for the largest proportion of fatal injuries.[21,22] Using machinery is also a hazard for occupational health problems such as chronic back pain and hernia,[8] whereas the use of chemical products and pesticides has been linked to skin problems, respiratory diseases, and poisoning.[23]

There is a range of situations where farmers can choose between performing healthy and safe or unhealthy and unsafe behavior. With regard to machinery use, unsafe behavior includes jumping off a tractor before it has come to a complete standstill, repairing machines with the engine running, using machinery for the wrong purposes, bad maintenance, overcharging, and allowing children near machines. An extreme example of unsafe machinery use is the removal of rollover protection devices that are meant to increase safety on tractors.[22] Unsafe handling of animals includes shouting at animals, not removing the horns from cattle, approaching animals from behind, and entering a small enclosed area with large animals.[13–15] Handling of chemicals and pesticides is hazardous when prescribed doses and safety periods are not respected; when products are used in wrong weather conditions, not stocked in a separate place, or not kept in the original packaging; and when hands or clothes are not washed after using chemicals.[23] Other behaviors that imply health or safety hazards are carrying heavy loads, working under the influence of alcohol,[24] working under time pressure[25] or when tired,[26,27] smoking in stables, using fire near inflammable materials, walking on roofs without protection, leaving materials scattered on the floor, and not using sunscreen when working in the sun.[12]

Although all of these risk factors have been well documented individually, there are very few studies looking at them in combination. As a result, it is unknown which behavioral risks contribute most to the occurrence of injuries and occupational diseases of farmers, and if there is an additional impact of nonbehavioral risk factors over and above the behavioral risks. Furthermore, it remains unclear to what extent these unsafe and unhealthy behaviors are more common amongst specific (sub)groups of farmers. This information would be very useful to target interventions aimed at preventing injuries and occupational disease. The present study addresses this issue by investigating the differential impact of behavioral and nonbehavioral risk factors for injury and disease among farmers, and by exploring the differences in self-reported health- and safety-related behavior among subgroups of farmers.

METHODS

Participants

The study population consisted of a representative sample of 1500 Belgian farmers, encompassing the two main regions of the country, that is, Flanders (Dutch-speaking) and Wallonia (French-speaking). The Flemish sample was selected using a data file from the Federal Public Service of Finance containing all VAT-registered enterprises, which allowed stratification by location and farming activity (agriculture, horticulture, animal farming). As a result, the sample reflected the distribution of farmers across the five Flemish provinces and the different farming activities. The French-speaking sample was selected using a data file from the Ministry of Agriculture of Wallonia, which only allowed stratification per province. Each farmer in the sample (750 from each region) received a copy of a questionnaire by mail in his or her own language, together with an accompanying letter, instructions, and a prestamped return envelope. Anonymity was guaranteed throughout the procedure. Since farmers are known for their low participation in surveys,[28] the possibility of winning a 25€ coupon was offered as an incentive to the Flemish participants. Because of financial constraints, this procedure was not used in the French-speaking sample. A reminder was sent to all participants four weeks after the original mailing.

Instrument

For the purpose of this study, a self-report questionnaire was used with four factor-analytically derived scales measuring health- or injury-related behavior via 28 Likert-type items (1 = strongly disagree, 5 = strongly agree). Machinery use was measured by 7 items (e.g., "Before I use a new machine I read the manual"); animal handling by 5 items (e.g., "I keep small children away from my animals"); fall prevention by 9 items (e.g., "I have my hands free to climb a ladder"); and pesticide use by 7 items (e.g., "I keep pesticides in a separate storage room"). High scores on the scales indicated healthy or safe behavior. The scales were part of a more encompassing questionnaire measuring health- or injury-related behavior and its determinants, which had previously been validated on a representative sample of 283 Flemish farmers.[29] Internal consistencies (Cronbach α) for the behavioral scales ranged between .60 (machinery use) and .89 (fall prevention). A French version of the questionnaire was developed using translation-back translation and validated on the current sample, showing internal consistency indices between .55 and .88. In addition to the behavioral scales, the questionnaire also contained a section asking for demographic characteristics (age, gender, education level), farm characteristics (type of farming, location of the farm, ownership, number of people employed, and function on the farm), and participation in safety-related training. The occurrence of injuries and work-related disease were each assessed by a single question asking the respondent if (s)he had suffered a work-related injury or a work-related disease in the past 12 months.

Statistical Analyses

Data were weighted to compensate for disparities between the sample and official Belgian statistics. Nonbehavioral and behavioral risk factors were first analyzed separately. To identify nonbehavioral risk factors for experiencing an injury or disease related to the farm activities, multivariate analysis using binary logistic regression was performed, with all demographic and farm characteristics entered as predictor variables and the occurrence of an injury and disease as dependent variables. As different sampling strategies were used for the two regions, regional differences were not included in the analyses. The results of the logistic regression are expressed as estimated odds ratios (ORs) with corresponding confidence intervals (CIs). Hosmer-Lemeshow tests were used to assess the goodness of fit tests.

Secondly, to identify the behavioral risk factors for the occurrence of an occupational injury or disease, forward and stepwise discriminant function analysis was applied, with the scores on the behavior scales entered as predictor variables and the occurrence of an injury and disease as dependent variables. Finally, to investigate the additional effect of nonbehavioral risk factors over and above the behavioral ones, demographic and farm characteristics measured at categorical level (i.e., age, education, farm ownership, main occupation, number of employees, and safety training) were entered in the discriminant function analysis as dummy variables, in addition to the scores on the behavior scales. To explore differences in health- and safety-related behavior among subgroups within the farming population defined by the demographic and farm characteristics, multivariate analyses of variance (MANOVAs) were performed. Subsequent univariate F tests were used to identify the behaviors that contributed to the multivariate differences. Since older people were expected to generally have a lower level of education than younger people, the interaction between age and education was also tested. All analyses were performed using SPSS 14.00.

RESULTS

Participant Response

A total of 510 completed questionnaires were returned (283 Flemish and 237 French), representing a response rate of 34% (37.7% for the Flemish and 31.6% for the Walloon farmers). The effective sample size was well above the minimum recommended sample size of 383 resulting from an a priori sample size calculation with a 5% error margin and 95% confidence level. Eighty percent of the respondents were male. Their age ranged from 22 to 85 years, with a mean age of 49.4 years ($SD = 12.56$). The mean age of the female respondents was 49.5 years ($SD = 13.55$), with ages ranging from 14 to 81 years. The respondents' education level ranged from low (lower secondary education or less; 46%), to average (secondary education and vocational training; 20%) and high (higher education; 18%). A majority of the participants (58%) worked on farms focusing on a single activity: 39% in animal confinement, 10% in crop-growing, and 9% in horticulture. The remaining 41% worked on mixed farms. Farming was the main occupation for 80% of the respondents, and 89% were owner or co-owner.

Prevalence of Occupational Injury and Disease

Of the 510 respondents to the questionnaire, 30 (5.9%) had suffered a work-related injury over the past 12 months. This is an incidence rate of 5736/100,000. More than double this number ($n = 62$, 12.2%) reported to have suffered an occupational disease during the same time period. On population level, this equals an incidence rate of 11,854/100,000.

Nonbehavioral Risk Factors

The results of the logistic regression revealed that the occurrence of a work-related injury was significantly related to education level and numbers of employees (Table 1). Farmers with a low or average education level reported lower injury rates, whereas farmers with a high education level had a much higher injury rate. With regard to number of employees, farmers working alone had the lowest risk of an occupational injury, and farmers working with one employee the highest; farmers with more employees showed an intermediate risk level for injuries. None of the other demographic or farm characteristics were significantly related to the occurrence of a work-related injury.

For the occurrence of an occupational disease, the logistic regression did not reveal significance for any of the risk factors. However, a nonsignificant age effect was found, giving a lower occurrence of occupational disease in the oldest group of farmers compared to the other groups.

Behavioral Risk Factors

Forward discriminant function analysis using safe machinery use, animal handling, fall prevention, and pesticide use as predictor variables and occupational injuries as the dependent variable did not produce a significant discrimination between farmers who had experienced an occupational injury and those who had not (Wilks' lambda = .987, $\chi^2(4, 504) = 6.653$, $p = .155$). However, when the stepwise method was applied, safe pesticide use was identified as a discriminator for occupational injury. As revealed by the structure matrix (Table 2), all four behaviors were highly correlated with the function discriminating between farmers with and without an injury, which classified 94% of the cases correctly. Univariate analysis of variance revealed significant differences between farmers with and without an occupational injury for pesticide use ($F(1, 502) = 5.503$, $p = .019$) and machinery use ($F(1, 502)= 4.121$, $p = .043$), whereas significance was approached for animal handling ($F(1, 502) = 3.870$, $p = .050$) and fall prevention ($F(1, 502) = 3.800$, $p = .052$).

For the occurrence of an occupational disease, forward discriminant function analysis with the scores on the four behavioral scales as

TABLE 1. Nonbehavioral Risk Factors for Occupational Injury and Diseases

	Injury					Disease				
	Frequency	%	OR	95% CI	*p*	Frequency	%	OR	95% CI	*p*
Gender										
Female	3/83	3.6	1.237	.294–5.205	.772	8/74	10.8	1.342	.526–3.422	.538
Male	26/380	6.8				54/338	15.9			
Age										
65+	4/64	6.3	.908	.155–5.318	.846	2/57	3.5	.175	.022–1.370	.349
50–64	11/159	6.9	1.620	.212–12.371	.914	24/139	17.3	.227	.028–1.860	.097
36–49	11/193	5.7	1.808	.153–21.296	.642	28/171	16.4	.284	.030–2.729	.167
≤35	4/54	7.4			.638	9/48	18.8			.276
Education										
Low	11/217	5.1	4.230	.940–19.039	.012	22/194	11.3	1.752	.653–4.699	.519
Average	7/147	4.8	10.028	2.158–46.602	.060	25/124	20.2	1.256	.533–2.959	.265
High	11/79	13.9			.003	11/78	14.1			.602
Farm ownership										
No	1/12	8.3	.508	.036–7.228	.617	1/13	7.7	0.008	.000–∞	.999
Yes	25/425	5.9				56/386	14.5			
Main occupation										
No	2/86	2.3	7.250	.806–65.188	.077	8/76	10.5	2.434	.834–7.101	.104
Yes	27/376	7.2				54/332	16.3			
Farming type										
Animal confinement	8/190	4.2	1.323	.211–8.290	.151	22/170	12.9	.707	.286–1.745	.647
Mixed	17/188	9.0	.403	.130–1.249	.765	30/166	18.1	.738	.363–1.499	.451
Crop/horticulture	4/88	4.5			.115	10/75	13.3			.401
No. of employees										
0	3/160	1.9	.177	.038–.821	.018	16/137	11.7	.784	.376–1.631	.808
1	20/192	10.4	.902	.117–6.923	.027	28/160	17.5	.862	.366–2.029	.514
2 or more	4/104	3.8			.921	13/91	14.3			.734
Safety training										
No	26/417	6.2	1.558	.268–9.065	.622	56/380	14.7	1.925	.620–5.976	.257
Yes	2/33	6.1				7/26	26.9			

TABLE 2. Means, Standard Deviations, and Structure Matrix for Behaviors Related to the Occurrence of Having an Occupational Injury or Disease

	Injury mean (*SD*)	No injury mean (*SD*)	Structure matrix	
			Forward DA	Stepwise DA
Pesticide use	3.401 (.566)	3.616 (.582)	.905	1.000
Machinery use	3.433 (.645)	3.664 (.600)	.783	.556
Animal handling	3.331 (.531)	3.575 (.672)	.759	.517
Fall prevention	3.702 (.679)	3.978 (.622)	.752	.589
	Disease mean (*SD*)	No disease mean (*SD*)	Structure matrix	
			Forward DA	Stepwise DA
Machinery use	3.397 (.694)	3.678 (.584)	.713	.715
Pesticide use	3.715 (.654)	3.982 (.619)	.652	.654
Animal handling	3.506 (.633)	3.604 (.569)	.259	.319
Fall prevention	3.513 (.677)	3.553 (.658)	.093	.093

predictor variables gave a significant discrimination (Wilks' lambda = .953, $\chi^2(4, 482) = 22.974$, $p < .001$). The structure matrix showed that machinery use and pesticide use contributed most strongly to this discrimination. Stepwise discriminant analysis gave comparable results, resulting in a discriminant function that could classify 86.9% of the cases correctly. Univariate analysis of variance showed significant differences between farmers with and without a disease for machinery use ($F(1, 480) = 12.030$, $p = .001$) and pesticide use ($F(1, 480) = 10.041$, $p = .002$), but not for animal handling ($F(1, 480) = 1.585$, $p = .209$) or fall prevention ($F(1, 480) = 0.205$, $p = .651$).

Behavioral and Nonbehavioral Risk Factors

A discriminant function analysis with age, education, farm ownership, main occupation, number of employees, and safety training added to the behavior scales as predictors of occupational injury produced a discriminant function that was comparable to the one obtained for the behavioral scales only (Wilks' lambda = .958, $\chi^2(10, 376) = 15.832$, $p = .105$). The structure matrix for this function identified education level as the factor that added most to the discrimination, followed by pesticide use. The values for animal handling, fall prevention, machinery handling, age, main occupation, safety training, number of employees, and farm ownership were much lower. Including the nonbehavioral factors in the discriminant function did not produce a higher percentage of correctly classified cases (94%).

For the occurrence of an occupational disease, a significant discriminant function was obtained for the combination of age, education, farm ownership, main occupation, number of employees, safety training, and the four behavior scales (Wilks' lambda = .935, $\chi^2(10, 374) = 24.705$, $p = .006$). Unsafe handling of pesticides and machinery use were the main discriminating variables, whereas the correlation with the discriminant function of the other variables was less important. Although the percentage of correctly classified cases increased slightly by including the nonbehavioral variables (87.3%), the nonbehavioral factors generally added little to the prediction of occupational disease.

Health and Safety Behavior of Subgroups

MANOVAs on the behavior scores for subgroups of farmers defined by demographic and farm characteristics revealed significant main effects for age (Wilks' lambda: .963, $F(12, 1624) = 1.936$, $p = .027$), gender (Wilks' lambda: .952, $F(4, 580) = 7.332$, $p < .001$), and number of employees (Wilks' lambda: .987, $F(8, 926) = 2.051$, $p = .017$), as well as a significant interaction effect for age and education

(Wilks' lambda: .063, $F(24, 2143) = 1.721$, $p =$ .016). For the other variables no significant multivariate differences were found ($p = .133$ for level of education and for farming type, .074 for farming as main occupation, .090 for ownership, and .414 for safety training). Results of the univariate F tests for subgroups defined by demographic characteristics (Table 3a) revealed that the multivariate effect for age could mostly be attributed to differences in the scores for machinery use ($p = .009$), in the sense that older farmers handled machines more safely. With regard to gender, significant differences were found for animal handling and fall prevention (both at $p < .001$), with women behaving safer than men on both variables. The significant interaction effect of age and education is mostly due to animal handling: in the oldest age groups (65+ and 50–64 years), farmers with the highest level of education handle animals more safely; in the group of 35–49-year-olds, the farmers with an average education perform best; and in the youngest group (<35), the lowest educated farmers report the safest handling of animals. Farmers with a low education generally behave more safely with animals than those with a high level and those with a middle level of education.

Univariate F tests for the behavior of the subgroups defined by farm characteristics (Table 3b) revealed that the multivariate effect for the number of employees is due to different scores for machinery use, although this difference is only marginally significant ($p = .081$). Significant univariate differences were also found for the type of farm and for farming as a main activity. Crop-growing farmers demonstrated the safest machinery use, followed by farmers in animal confinement and horticulture, whereas farmers on mixed farms used machinery less safely. Machinery use and animal handling were also less safe when farming was a main occupation than when the farmer had another occupation for a main activity, and respondents who owned their farm reported safer pesticide use than nonowners. In contrast, no differences in behavior were found between farmers who had and who had not participated in safety training.

TABLE 3a. Means, Standard Deviations, and Significance Tests for Health- and Safety-Related Behavior Among Subgroups of Farmers Defined by Demographic Characteristics

	Mean (standard deviation)				Univariate F	p
	Gender					
	Male	Female				
Machinery use	3.630 (.029)	3.721 (.045)			2.908	.089
Animal handling	3.567 (.032)	3.781 (.043)			17.085	.000
Fall prevention	3.518 (.032)	3.782 (.050)			19.687	.000
Pesticide use	3.941 (.031)	4.041 (.047)			3.167	.076
	Age					
	≤35	36–49	50–64	65+		
Machinery use	3.318 (.101)	3.617 (.041)	3.617 (.069)	3.849 (.130)	3.876	.009
Animal handling	3.544 (.098)	3.577 (.040)	3.638 (.067)	3.617 (.126)	.295	.829
Fall prevention	3.290 (.109)	3.523 (.045)	3.531 (.074)	3.770 (.140)	2.539	.056
Pesticide use	3.852 (.110)	3.978 (.045)	3.858 (.075)	3.995 (.141)	.904	.439
	Education					
	Low	Middle	High			
Machinery use	3.660 (.073)	3.533 (.067)	3.607 (.095)		.826	.438
Animal handling	3.705 (.071)	3.419 (.065)	3.658 (.092)		4.933	.007
Fall prevention	3.619 (.079)	3.482 (.072)	3.484 (.103)		.956	.385
Pesticide use	4.003 (.080)	3.880 (.073)	3.880 (.104)		.766	.295

TABLE 3b. Means, Standard Deviations, and Significance Tests for Health- and Safety-Related Behavior Among Subgroups of Farmers by Farm Characteristics

	Mean (standard deviation)				Univariate F	p
	Farm type					
	Animal confinement	Crop-growing	Horticulture	Mixed		
Machinery use	3.650 (.043)	3.863 (.086)	3.644 (.090)	3.594 (.042)	2.640	.049
Animal handling	3.553 (.041)	3.783 (.083)	3.693 (.086)	3.603 (.040)	2.439	.064
Fall prevention	3.535 (.047)	3.675 (.095)	3.579 (.099)	3.558 (.046)	.591	.621
Pesticide use	3.899 (.045)	4.104 (.090)	4.048 (.094)	3.970 (.044)	1.774	.151
	Farm ownership					
	No	Yes				
Machinery use	3.520 (.092)	3.640 (.028)			1.584	.209
Animal handling	3.615 (.087)	3.587 (.026)			.095	.758
Fall prevention	3.536 (.099)	3.542 (.030)			.004	.952
Pesticide use	3.756 (.096)	3.954 (.029)			3.955	.047
	Farming as main occupation					
	No	Yes				
Machinery use	3.773 (5.064)	3.626 (5.030)			4.247	.040
Animal handling	3.720 (.062)	3.583 (.029)			4.027	.045
Fall prevention	3.590 (.071)	3.560 (.033)			.146	.703
Pesticide use	3.942 (.031)	4.056 (.067)			2.412	.121
	Number of employees					
	None	1	2 and more			
Machinery use	3.732 (.047)	3.590 (.043)	3.633 (.057)		2.530	.081
Animal handling	3.639 (.046)	3.578 (.042)	3.633 (.056)		.572	.565
Fall prevention	3.529 (.052)	3.561 (.048)	3.610 (.064)		.490	.613
Pesticide use	3.936 (.049)	3.958 (.045)	4.031 (.059)		.813	.444
	Safety training					
	Yes	No				
Machinery use	3.629 (.029)	3.654 (.102)			.056	.813
Animal handling	3.581 (.027)	3.633 (.098)			.263	.608
Fall prevention	3.547 (.032)	3.444 (.113)			.773	.380
Pesticide use	3.936 (.030)	4.019 (.106)			.562	.454

DISCUSSION

The main goal of this study was to investigate the impact of behavioral and nonbehavioral risk factors for farm-related injuries and diseases in a representative sample of Belgian farmers. As such, this is the first study to extensively investigate the health and safety of farmers in Belgium. The results showed that in the 12 months preceding the study, almost 6% of the farmers surveyed had suffered a work-related injury, and more than 12% had suffered an occupational disease. This represents an incidence rate of 5736/100,000 and 11,854/100,000 at population level. These incidence rates fall well within the range of rates that have been reported internationally. For example, the incidence rate for (nonfatal) injuries among farmers in the United States decreased from 11.7 per 100 farmers in 1981 to 7 per 100 in 2001[30]; in Ontario, Canada, it is 5.8 per 100 persons per year[31]; and in Denmark 45.2/100.[12] The fact that these incidence rates vary so widely is probably due to the use of different data sources, which include official data banks, administration of hospital admissions and emergency care unit, general practitioner consultation, and surveys. In many countries there is no legal or administrative obligation to collect information on injuries among farmers.[16] This is also the case for Belgium, where the latest official data regarding injuries and occupational diseases are from 2001. Since then, questions regarding safety were removed from the agricultural census. Another reason for the variability of incidence rates may be the different interpretation of "injury," "accident," and "disease." Whereas in many studies only severe injuries and diseases are included, the present study asked farmers to report any work-related injury or disease that had occurred during the past year, regardless of the consequences or severity. The fact that despite this subjective approach the incidence rates that were found appear to be comparable to those found elsewhere attests to the reliability of the study.

To identify the risk factors for occupational injuries and diseases, most studies either investigate demographic characteristics such as age, gender, or socioeconomic status; the working environment context such as farm size, farm type, or seasonal conditions; or behaviors that increase the risk for injuries or disease. The present study considered both nonbehavioral and behavioral risk factors, thus allowing for a comparison of their relative importance. The results indicate that of the nonbehavioral factors only the education level and number of employees were significantly related to occupational injuries. Highly educated farmers more often reported an injury than those with a low or average education, and farmers working with one employee had fewer injuries than those working alone or with a high number of employees. In contrast, age, gender, and type of farming were not related to injuries, and none of the demographic factors were related to occupational disease.

With regard to the behavioral factors, the results show a relationship of occupational injuries with unsafe pesticide use and machinery use, and to a lesser extent also with fall prevention and animal handling. Unsafe machinery and pesticide use were also the main risks for occupational disease. Moreover, when behavioral and nonbehavioral factors were analyzed jointly, the prediction of injuries or disease was not better than when behavioral factors were considered alone, which suggests that the additional effect of nonbehavioral risk factors over and above the behavioral ones is limited. As such, these findings lend support to the hypothesis that unsafe or unhealthy behavior is the main determinant of occupational health and safety of farmers, and that farmers' behavior must be taken into account for the development of preventive interventions.

Given the importance of these behaviors, it is meaningful to investigate their prevalence in relevant subgroups within the farming population. The second goal of the study was therefore to look at the differences in health- and safety-related behavior among subgroups of the sample, defined by demographic characteristics and working environment. With regard to demographic characteristics, significant differences in risk behavior were found between groups of farmers defined by gender and age, in the sense that older farmers reported safer handling of machines, and that women behaved more safely than men in handling animals and preventing falls. This is in line with the results of other studies showing that male[32] and younger farmers[33,34] engage more often in risky behavior. In addition, an interaction effect was found between age and education level. In the older age group, animal safety practices were better among those with the highest level of education; in the group of 35–49-year-olds, farmers with an average education behaved more safely; and in the youngest group, those with the lowest level of education. When only taking education into account, farmers with a low education performed the safest behavior towards animals, and those with an average level the least safe. This finding is at odds with other studies showing that higher education is associated with more safely oriented attitudes and intentions.[34]However, this may be due to the interaction of education and age: highly educated people are more often found among younger farmers, who engage more in risk-taking behaviors.[33,34]

With regard to farm characteristics, significant differences in behavior were found for subgroups defined by the type of farm, number of employees, farm ownership, and whether farming was a main occupation. Crop-growing farmers demonstrate the safest behavior in machine handling, and farmers on mixed farms the least safe behavior. This may be due to the nature of the work on crop-growing farms, which is characterized by less variety of tasks than mixed farming, and as such allows farmers to be more safety conscious while performing these tasks. Secondly, when farming is the farmers' main activity, lower safety levels are reported for machinery use and animal handling. It may be that persons who are not farming full time feel less confident in handling machinery and animals and therefore pay more attention to possible risks. On the other hand, farm owners displayed safer pesticide use than nonowners. As they are responsible for the pesticide-related tasks on their farm, farm owners may be more aware of the pesticide-related risks than other employees who only use pesticides occasionally.

The finding that subgroups of farmers show different levels of risk behavior is important for developing prevention programs. Apart from being useful to identify the key target groups for selective interventions, it also implies that a "one-size-fits-all" approach to prevention is unlikely to be effective. Instead, it seems more appropriate to develop more "tailor-made" interventions, which better suit the needs of the different groups within the population of farmers. In this regard, it is important to point out that also in our study farmers who had participated in a safety training program did not score significantly better on the health and safety practices than those who had not. Indeed, existing health and safety trainings for farmers often entail a uniform approach aimed at enhancing knowledge and raising awareness towards more safety. Recent reviews suggests that preventive interventions for farmers' health and safety make insufficient use of behavior change theories and methods,[35,36] and that prevention efforts could more effective by including these methods. The current findings complement this view by suggesting that preventive interventions may also need to be more differentiated towards specific subgroups. Further investigation of the way existing prevention programs match the needs of different target groups should clarify this issue and thus contribute to the development of more effective prevention programs for farmers.

The study is not without its limitations. Firstly, as a cross-sectional investigation utilizing self-report questionnaires, the study does not provide objective data on the incidence of occupational injuries and diseases among farmers in Belgium, only data on perceived health and injuries. To have a more objective incidence measures, registrations of hospital and emergency care unit admissions or general practitioner consultations should be used. However, as information on farm injuries or diseases is not systematically collected in Belgium, self-reported health and injuries provide a useful estimation of the incidence. The fact that the incidence rates found in this study are comparable to those reported in the international literature suggests that they provide a fairly accurate estimation. Similarly, the behavioral risk factors that are investigated in this study were also measured by self-reports. Although on-site observation and registration of these behaviors would have provided more objective data, it would not have been practically feasible to carry out such an observation study in a large group of farmers, and to compare the occurrence of these behaviors in subgroups. On the other and, the behavioral risks of interest were assessed by means of validated scales, and can therefore be considered as valid behavioral measures. Finally, the study looked at the relationship between behavioral and nonbehavioral risk factors and the occurrence of occupational injuries and diseases in general, without establishing a link between specific risk factors and specific injuries or diseases. Although it seems likely that certain risk factors are associated with specific health outcomes (e.g., machinery use is a hazard for chronic back pain or traumatic lesions, and chemical product use enhances the risk for poisoning and respiratory diseases), the lack of specificity of the health outcome measures did not allow an investigation of these specific relationships. Also, it was not possible to investigate "dosage" effects, that is, the relationship between the level at which risk behaviors are performed and the seriousness of the resulting injuries or diseases. These aspects could be the subject of further research, which could investigate the relationship in more depth.

CONCLUSIONS

Agriculture is a hazardous and unhealthy occupation that is characterized by a high incidence of work-related injuries and health problems. Although it is generally known that these problems are caused by a combination of demographic, environmental, and behavioral factors, the relative contribution of these factors is not always clear. The present study shows that if behavioral and nonbehavioral risk factors for injury and disease among farmers are considered jointly, the additional effect of nonbehavioral risk factors over and above the behavioral ones is limited. Although education level and number of employees on the farm are related to occupational injuries, the latter are more strongly influenced by unsafe use of pesticides and machinery, and to a lesser extent also by unsafe animal handling and inadequate falls prevention. Unsafe machinery and pesticide use were also risks for work-related disease. Significant differences in self-reported behavior were found for gender, age, number of employees, and the interaction between age and education. The study highlights the importance of behavioral factors as determinants of occupational injuries and diseases among farmers, and suggests that tailored preventive interventions should be developed to accommodate for differences in these behaviors among subgroups of farmers.

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